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ABSTRACT

A collaborative software development project designed to maximize the skill sets and interests of school children and teachers, educational software technologist and researchers, and college undergraduates is presented. The work brings together elementary school children with college seniors and technology consultants to implement a problem-solving methodology within a collaborative environment to design, develop and implement a multimedia software application that enhances the spatial orientation abilities of children and puts the programming, interface design and multimedia systems capabilities of college students into action. This effort in project-based learning offers young students the opportunity to learn mapping skills, problem-solving techniques, and participatory design methods while planning and conducting virtual tours of their city. (Author)

Participatory Design, Problem Solving and Community Involvement in Two Different Learning Communities

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Abstract

A collaborative software development project designed to maximize the skill sets and interests of school children and teachers, educational software technologist and researchers, and college undergraduates is presented. The work brings together elementary school children with college seniors and technology consultants to implement a problem-solving methodology within a collaborative environment to design, develop and implement a multimedia software application that enhances the spatial orientation abilities of children and puts the programming, interface design and multimedia systems capabilities of college students into action. This effort in project-based learning offers young students the opportunity to learn mapping skills, problem-solving techniques, and participatory design methods while planning and conducting virtual tours of their city.

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Introduction

Familiarity with geography, the science of space and place on the Earth's surface, helps people visualize and understand their home and orients their relationships vis-à-vis other cultures and environments. Maps help to show children where they are, where they've been and where they can go, while creating a sense of belonging to a community, a history and a path to the future. The urban environment, in particular, is populated with many young students who do not often perceive their world beyond the boundaries of their immediate neighborhood.

We describe here a software development collaboration project designed to maximize the skill sets and interests of elementary school children and teachers, educational software technologist and researchers, and college undergraduates. Through the implementation of project-based learning, problem-solving and, participatory design methodologies, and community involvement, software containing interactive video, calculation programs and spatial orientation tools offers 4th- through 6th-grade students in Newark, New Jersey the opportunity to learn mapping skills while planning and conducting virtual tours of their city.

Cognitive Development, Spatial Orientation and Technology

Learning theorists have articulated unique developmental predispositions for different kinds of learning. David Sobel (1998) states that between ages five and seven, children start to move away from home and parents and explore the natural world. From ages seven to eleven, children are predisposed to merging with nature and making geographic sense of the world around them. Although computers cannot replace the human contact and feedback that only a teacher can provide, they are tools that can be used to significantly enhance students' educational experiences at a time when children have a propensity to explore. Through the process of participatory design (Druin, 1999), 10-year old students have an equal, if not greater stake in the development, testing, refinement and use of the software as compared to the college students who are interacting with the youngsters at each stage and step of the software development process.

Software companies have developed a wide range of software applications geared to geographic inquiry and map making. The current strategies used in mapping software programs permit students to be active mapmakers. Neighborhood Map Machine, Trudy's Time and Place, Carmen Sandiego, Where Are We, Map Makers Tool Kit, Geo Safari – all introduce geography skills to students grade 4–8, geared to providing geographic discovery and knowledge. What these programs cannot offer, however, is any significant or concrete local context for the user. Moreover, educational software applications generally do not satisfactorily support the urban environment. Their symbols are suburban in orientation, and many of their activities use rural landscapes as a backdrop to learn navigating skills. However, children often do not have an opportunity to explore their neighborhoods. Urban lifestyles sometimes include dangers in neighborhoods and deplorable conditions of many buildings, causing parents to be reluctant to have their children explore on their own.

We've developed a partnership among students and faculty at the New Jersey Institute of Technology, Little Bytes, a technology-integrated curriculum development firm, and St. Philip's Academy, an independent elementary school in Newark, to serve as the foundation for a comprehensive multiyear program in multimedia learning systems that brings college seniors studying software engineering and multimedia design together with elementary school students and teachers in an effort to provide community-based educational software that introduces children to the landmarks and cultural facilities of Newark through the collaborative development of mapping skills instructional software. A major goal of the program is to build on the participatory design model of software design, articulated most clearly for application in an educational environment by Druin (1999), and a problem-solving methodology that has been successfully implemented at NJIT and in four Newark public high schools (Deek, 1997; Deek & Friedman 2001). We are testing the hypothesis that integrating these two models will promote positive change in the academic climate of classrooms by incorporating teachers, students and skilled college-level software engineers to create educational multimedia applications that accommodate the specific needs of the younger students, provide teachers with design-level access to appropriate instructional materials and educational technologies, and give youngsters hands-on experience in the design, development, testing and use of computer software tools.

Our project began with Little Bytes, a client of NJIT's business incubator providing the content specifications to begin building the software application. The NJIT/Little Bytes collaboration has opened the door to increased involvement with community-based and civic organizations such as the Newark Museum, Newark Bears baseball team, New Jersey Performing Arts Center, the Newark Housing Authority and the Newark Department of Engineering, all of whom have contributed to the development of a mapping skills software application that is focused on Newark's neighborhoods and landmarks. Having already placed several college students, earning service learning credits, at St. Philip's Academy, where Little Bytes serves as educational technology consultant, we were well positioned to expand our involvement to include a small class of seniors to focus on a specific outcome.

Project Implementation

During the spring 2002 semester, NJIT seniors majoring in multimedia information technology, information systems and computer science, were more enthusiastic to be involved in this innovative project. The college students' educational experience is project-based, as it moved them out of the lecture hall and into the community and the computer lab as they worked with learning systems researchers, 4^{th}–6^{th}

grade students and educational technology consultants to implement a software design that was created collaboratively among St. Philip's Academy 4th grade school students, their teacher and Little Bytes. The software's three major components begins with a series of fun tutorials facilitated by an animated character, during which the user learns basic geography skills; putting those skills to use as they conduct four searches throughout different locations in Newark, and finally being able to design virtual tours of the city by building efficient routes between landmarks that are in video format.

The protocols of the project are oriented to maximize a problem-solving methodology found effective in computing, mathematics and composition courses at the pre-college and college levels (Deek & Friedman, 2001), combined with Druin's approach to software engineering (Druin, 1999). Children's interaction with technology expands beyond their end-user status and into the conceptual design, development, usability testing and debugging phases as well. By involving the children, we supply an alternative method of software design, development and evaluation, one that is accessible to our end users, the elementary school students. Through the use of visually oriented software design and increased opportunities to team children, teachers and software engineering students, educational researchers and software designers in the development of new applications, software evaluation becomes the province of all the participants.

Application development through participatory design has three main goals: to develop integrated learning environments that support visual and verbal literacy; to encourage student centered learning; and, to develop methodologies that offer a better understanding of what children want and need when using technology. The program provides a combined laboratory and classroom environment in which participants design, develop, test and refine software tools intended to inculcate spatial awareness and mapping skills while also attaining positive results with students.

Problem-Solving

Through participatory design, there are extended interactive discussions among teachers, students and software engineers during each phase of software development. We began with a meeting of all the people involved: the 4th graders, their teacher and principal; the college students and their instructor, two representatives of a community based youth group, Do Something Newark; and two educational technology consultants from Little Bytes. After explaining to the youngsters briefly what we had in mind, the children were asked to describe and draw a picture of a character that would act as their guide through the computer game. The college students formed several groups: graphical user interface designers, database and systems programmers, videographers and 3D designers, and each began to storyboard specific components of the intended product.

There are three major components. Section 1, Navigator, consists of 11 skill building interactive exercises that teach basic map reading skills. Here, an animated character that acts as a guide, Mapper, is introduced. Section 2, Mad Mysteries, presents three scenarios in which students find answers to clues offered in each to solve mysteries that take place in Newark. They are awarded certificates of proficiency that allow them to move on to the final component, Section 3, Create a Tour. The children are given a problem to solve: how to structure a tour of Newark for four different groups of tourists, all with different time constraints as well as interests. The skills garnered in Section 1 and tested in Section 2, are applied in Section 3. After two weeks of preliminary design, the college students settled on Macromedia Flash as the animation and movie creation software best suited for sections 1 and 2, and Adobe Digital Video Suite served as the main technology behind section 3.

Employing a consistent methodology that is common to all the participants and able to be documented added to the sense of partnership among the participants as they shared ways to solve problems specific to the areas that each encounter. Bringing theory into practice, as Filho (2001) suggests, demands that a process architecture be used when students are engaged in complex software engineering projects such as the project describe here. We used SOLVEIT, which is such an architecture, and has been successfully employed in high school and college settings. (Deek & Friedman, 2001) The SOLVEIT environment is collection of tools supporting a six-step process for problem solving and software design and implementation. These steps are: formulating the problem, planning, designing, and translating the

solution, and finally, testing and delivering the product. The combination of a participatory design approach and SOLVEIT as a software engineering methodology produced a highly accessible interactive software application. NJIT students used applications such as Flash, 3D StudioMax, Adobe Digital Video Suite, as well as C++, Java and Access to provide the younger students with a game-like learning environment. This combination of methodologies and tools not only broadens all the students' educational experience, but also provides a more meaningful context within which to integrate the knowledge and skills they have garnered.

Student Response

While the college students were initially hesitant to break free of their traditional classroom environment, they were quick to appreciate the benefits of working within the structure provided by SOLVEIT as well as those that problem-based learning experiences offer, particularly when the solution to a problem takes the form of interactive software, and the design and development of that software is based in the methodology of participatory design. Ritika, who was responsible for the scaling activity in the Navigator group, used Flash 5

> because the class had agreed on doing most of the project with it. Also, it was something new to me, and I wanted to learn it. I tried to think of the kids' demands first when I was making this, so I tried to make it as fun as possible. I put in animations, and will put in sounds, which I think they will enjoy. From the last meeting with the kids, I could tell they wanted something very challenging with degrees of difficulty, but I am not sure how to incorporate that into my part of the game. (Instructor's notes)

Marc was part of the audio/video team responsible for the planning, shooting, editing, and integration of video footage and voice-overs. In a mid-semester report he noted,

> The recent visit by the St. Philip's students to our NJIT lab led to the continued development of software segments that have thus far been pieced together. The students' ideas reflect their upbeat attitude toward the city of Newark and their role in the project. An example of their input during this meeting was the idea to change the background color at the welcome screen from a black night to a more optimistic daytime. Jerri, Ursula [of Little Bytes] and AJ [Zenkert, the 4th grade teacher] have all been a big help. Ursula is good at clearing up confusing development issues between Jerri and our NJIT class. I look forward to our future collaborations. (Instructor's notes)

Rajesh, who in addition to the credits is responsible for several of the Navigator components, used Macromedia Flash, Adobe Illustrator, Microsoft Paint, and Microsoft Image Composer as development tools.

> These were chosen for their development capabilities and ease of use. On average, in addition to class time, I spent about 5 hours a week on the project. Initial progress was slow because of the learning and investigating time involved in starting the project. Meeting with Jerri, Ursula, AJ, and the St.Philip's kids proved that the users need a fun, challenging, and educational application. (Instructor's notes)

Gosia & Tim began their work by developing the introduction sequence for the software.

> We used traditional storyboarding and drawing techniques to develop the intro Space animation. We tried to make an entertaining and fun animation that hoped to show the kids from St. Philip's their perspective by traveling from space, down through the solar system, into New Jersey. Music was added to give a little flavor to the work using a hardware synthesizer, along with other software. Working in the studio environment with all the very diverse people was unarguably the best experience I have had since being at NJIT. (Instructor's notes)

Nainsi and Parag found that,

> This class has given a wonderful opportunity very close to the real world without entering a REAL world. Our project was mainly created by Flash; I have learned lot about Macromedia Flash and its implementing capabilities. Drawing with details and putting every piece together is sometimes tedious. But overall it is fun. Our discussions among ourselves, Jerri and the kids have shaped our requirements tightly. I really like the involvement of kids in our project, as I find them smart is noticing things and accurate in demanding what exactly they will like to see. What I don't like sometimes is not having a set rule, not knowing what actually is needed until it is done halfway or all the way. But I guess that is part of learning, and I don't have many complaints about that. (Instructor's notes)

St. Philip's Academy students and teachers have also benefited from this project in many different ways. The current Social Studies curriculum does not contain many lessons about mapping and map usage. Quality supplemental mapping skills material are not easy to find, particularly material that involves the type of mapping that is most pertinent to urban students' world: the city. When students understand how to use maps and concepts of scale and distance, they have skill sets that can be applied in subject areas such as history, politics, wars, migration, and immigration.

For the students, the opportunity to participate in the development of software is invaluable. Being a part of a team, whether it is a sports team or a debate team, teaches children about working together, solving problems, listening to others' ideas, and communicating. Throughout this process, the students have had to use and improve all of these skills. What they did not realize was that they learned and reinforced many mapping skills without ever sitting through a traditional classroom lesson. The students were very eager and excited to be a part of the project, and they worked very hard to be helpful, honest and creative in the process. They began to understand that they could not have everything they wanted in the software, but that it did not hurt to offer ideas and attempt to help, with the hopes that their ideas would be used in the final product. The teamwork, brainstorming, and creative thinking that the students used during this process provided a wonderful challenge and learning experience for them.

During a recent usability testing session, 14 4^{h} graders reviewed several components of the Navigator section, including a parade that asks them to measure distance and height, and assess whether a float will be able to pass under a bridge, a "walk in the park," which tests students' ability to orient themselves to shifting directions, and a "legend" exercise that asks students to identify icons and move them in their appropriate places on a map. Feedback was obtained concerning levels of difficulty, "coolness," as well as descriptions of what the students learned. These results have direct bearing on the nature of the modifications the college students will do over the summer, but also suggest that we are on the right path, not only in terms of integrating software into the 4th grade curriculum, but also that involving the children in the design and development of the software has proven beneficial to the younger participants of the project. The majority of children found the software to be "cool," the instructions clear and the navigation easy. There was a nearly unanimous call for the components to be more challenging, but at the same time, more children found the software to be fun than boring. When asked, "What did you learn while playing this activity?" ten of the 14 respondents answered, "How to measure," while the remaining four replied, "Nothing." When asked, "If you could change this activity in any way, what would you change?" about half answered, "Make it easy," two said, "Make it more challenging," and four did not respond. Generally, the students liked the interactivity and that the activities require concentration.

Conclusion and Future Work

Development and utilization of customized educational software empowers the teacher and takes advantage of rapidly emerging multimedia technologies. We expand our scope and vis ion by bringing together the classroom teacher, students, the business community, civic institutions with the universities to create technology integrated products designed to promote student-centered learning which serves the

community and ensures educational success of the child. The first version of City Mapping is designed primarily for 4th graders. It is our plan to produce a module for 5th and 6th graders as well during the fall 2002 semester. At the time, we will also expand our technology integration into the elementary school curriculum by implementing an international media sharing collaboration among students in Indonesia, Poland and Newark, with NJIT students building the infrastructure that will allow the exchange and collaborative development of music, art and narrative via the Internet.

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